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Microwave Emission Related to Cyclotron Instabilities in a Minimum-B Electron Cyclotron Resonance Ion Source Plasma

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Electron cyclotron resonance ion sources (ECRIS) have been essential in the research and applications of nuclear physics over the past 40 years. They are extensively used in a wide range of large-scale accelerator facilities for the production of highly charged heavy ion beams of stable and radioactive elements. ECRISs are susceptible to kinetic instabilities due to resonance heating mechanism leading to anisotropic electron velocity distribution function. Instabilities of cyclotron type are a proven cause of frequently observed periodic bursts of “hot” electrons and bremsstrahlung, accompanied with emission of microwave radiation and followed by considerable drop of multiply charged ions current. Detailed studies of the microwave radiation associated with the instabilities have been performed with a minimum-B 14 GHz ECRIS operating on helium, oxygen and argon plasmas. It is demonstrated that during the development of cyclotron instability “hot” electrons emit microwaves in sub-microsecond scale bursts at temporally descending frequencies in the 8-15 GHz range with two dominant frequencies of 11.09 and 12.59 GHz regardless of ECRIS settings i.e. magnetic field strength, neutral gas pressure or species and microwave power. The possible energy range of the electron population amplifying plasma waves is estimated and arguments on possible excited plasma wave modes are given.